

CSE 4360 / CSE 5364

Autonomous Robots

Fall 2021 - MW 5:30 - 6:50 - CRB 114 / Microsoft Teams

Instructor: Manfred Huber (huber@cse.uta.edu)

1 Instructor Information

Instructor: Manfred Huber

Office Number: ERB 128 or ERB 522

Office Telephone Number: (817) 987 6576

Email Address: huber@cse.uta.edu (please indicate the course number in the subject line)

Faculty Profile: <https://mentis.uta.edu/explore/profile/manfred-huber>

Office Hours: MW 3:00 - 3:45, MW 7:00pm - 8:00pm

2 Course Information

Course Delivery:

This course is an in-person course with group project components. However, all class periods will also be live-streamed on Microsoft Teams, allowing students to participate in class remotely if they so desire (this also applies to the course Quizzes - but not the exam - which will be at the beginning of class and accessible either in person or on-line). Classes will meet on Mondays and Wednesdays from 5:30 to 6:50 in CRB 114. Until September 8, due to the capacity of rooms being limited to 50%, the class will be Hybrid with Students with last names starting with a letter from A - L being in-class on Mondays (with Wednesday classes on-line on Teams) and students with last names starting with a letter from M - Z being in class on Wednesdays (and on-line on Teams on Mondays).

A large part of the course work will be in the form of group projects. For this, groups of 3-4 students will be formed that will stay together for all projects. As the Robotics Teaching Laboratory would be too tight a space, groups will be given the experimental robot platform kits into their custody and have to find their own project space where they can perform the robot projects. Project demonstrations will be scheduled with each team individually and be held in the Robotics Teaching Lab (ERB 207) which will also be available upon request for some testing activities. Similarly, the exam in the course will be held in-person in the classroom.

Contents and Objectives:

This course is an introduction to Robotics from a computer science perspective and aimed at establishing the basis for the design and programming of autonomous robot systems. It covers basic kinematics, dynamics, and control as well as motion planning, sensors, and artificial intelligence techniques for robot applications. Emphasis is given to the application of these techniques to simulated and real robots. Throughout the course students will work individually and in groups to analyze robot control problems and to design hardware and software solutions. Students successfully completing this course will be able to write basic control programs for different robot platforms and to apply state-of-the-art artificial intelligence techniques to the control of robotic mechanisms.

Prerequisites:

Prerequisites include CSE 2320. Of particular importance is knowledge of the programming language C since all programming assignments will be using this language.

Course Materials:

This course draws from a number of different books. Selected parts of other textbooks will be used as part of the course readings. Copies of these materials will be available through Canvas. These textbooks include:

- John J. Craig, *Introduction To Robotics*, Addison Wesley
- Jean-Claude Latombe, *Robot Motion Planning*, Kluwer Academic Publishers
- H. R. Everett, *Sensors for Mobile Robots*, A K Peters
- Dana H. Ballard and Christopher M. Brown, *Computer Vision*, Prentice-Hall
- L. Dorst, M. Lambalgen, F. Voorbraak (Eds.), *Reasoning with Uncertainty in Robotics*, Springer
- Alberto Elfes, *Using Occupance Grids for Mobile Robot Perception and Navigation*, in IEEE Computer 22(6)
- W. Burgard, D. Fox, D. Henning, T. Schmidt, *Estimating the Absolute Position of a Mobile Robot Using Position Probability Grids*, in Proc. of AAAI 1996
- Valentino Braitenberg, *Vehicles*, MIT Press
- Ronald C. Arkin, *Behavior-Based Robotics*, MIT Press
- S. Haykin, *Neural Networks*, Macmillan Publishing

Additional course materials such as assignments and example solutions will be available electronically on Canvas. Changes and corrections, if any, will also be announced by e-mail

Technology Requirements;

Every student will have to have access to a computer and Microsoft Teams to be able to participate in lectures for the first weeks of the semester. Students are expected to have a webcam and should have this camera turned on during lectures to be able to effectively participate in the class. In addition, students will have to have access to a computer to perform the programming components of the assignments and projects. For the latter, programming will occur preferably in a Linux environment but can also be installed under Windows and OSX. We will distribute a VirtualBox virtual Ubuntu image including the required software for the projects.

Computer Access:

This course will use UNIX as the operating system for all programming assignments. For this purpose all students will have access to computers in the Robotics Teaching Laboratory and to OIT supported unix computers (e.g. Omega) Additional details will be announced in class.

Note that for projects, each student group will have to have access to their own computer.

Tentative Course Office Hours:

Office hours for the course will be held by the instructor in ERB 128 or his office in ERB 522 on MW 3:00 - 3:45 and MW 7:00 - 8:00, or by appointment. The instructor will also be available on Microsoft Teams during those times. Times are subject to change and will be posted. If for some reason you can not make it to any of these office hours, please inform the instructor.

e-mail: huber@cse.uta.edu

When contacting the instructor by email, please indicate the course number in the subject line of the email. Faculty profile: <http://www.uta.edu/profiles/manfred-huber>

GTA Information:

Information about the Teaching Assistant will be announced in class and posted on Canvas.

E-mail and WWW page:

There is a course web page at <http://ranger.uta.edu/~huber/cse4360> . All changes and supplementary course materials will be posted on Canvas as well as on this site. In addition, necessary changes or important announcements will be distributed by e-mail. By default e-mail will be sent to your UTA account.

3 Assignments and Grading

Homework Assignments:

There will be 4 individual homework assignments in this course. The assignments consist of written parts as well as programming exercises on simulated robot mechanism and are due on the date indicated on the assignment. Solutions will be posted shortly after on Canvas. Homework solutions must be your individual work only. Violations of this will not be tolerated and result in severe penalties for all parties involved.

All assignments are graded out of 100 points. Assignments submitted late will be penalized, at a rate of 4 penalty points per hour. The submission time will be the time shown on Canvas. Any assignment submitted more than 25 hours late will receive no credit for the assignment. To receive credit for the assignment portion of the corresponding quiz you will have to hand in an assignment before the quiz.

Projects:

For the 3 projects groups of 3-4 students will be formed. Each project will involve designing and programming of a real robot system to solve a given task. At the end of each project, the programmed robot system has to be presented and a project report describing the design decisions made has to be delivered. Project presentations will be in person in the Robotics Teaching Lab (ERB 207) and reports will be due on Canvas. No extensions are generally granted for projects. If for any reason you can not finish the project or deliver the report in time, inform the instructor as early as possible.

Quizzes:

There will be 5 quizzes, each to be held at the beginning of the class after the first two assignments or projects were due. Quizzes will test knowledge of material taught in the course as well as of the assignment submitted. These quizzes can be taken either in-person in the class or on-line using the Canvas Lockdown Browser.

Exam:

The exam will be held in the class after the last assignment was due and has to be taken in-person in the classroom. It is closed book, closed notes and will cover the materials until “Adaptation and Learning” with an emphasis on the more theoretical aspects. As in the case of homework extensions, a make-up exam will only be given in extreme situations. If for any such reason you can not attend the exam, inform the instructor.

CSE 5364:

For students enrolled in the graduate section CSE 5364 the homework assignments, as well as the exam will contain additional problems which are not required for students of CSE 4360.

Attendance:

At The University of Texas at Arlington, taking attendance is not required but attendance is a critical indicator in student success. Each faculty member is free to develop his or her own methods of evaluating students' academic performance, which includes establishing course-specific policies on attendance. As the instructor of this section, I will require course attendance (in class or live on Teams) and attendance and participation will contribute to the course grade. Note that you are responsible for any course content covered in class irrespective of it being in the class notes. However, while UT Arlington does not require instructors to take attendance in their courses, the U.S. Department of Education requires that the University have a mechanism in place to mark when Federal Student Aid recipients begin attendance in a course. UT Arlington instructors will report when students begin attendance in a course as part of the final grading process. Specifically, when assigning a student a grade of F, faculty report the last date a student attended their class based on evidence such as a test, participation in a class project or presentation, or an engagement online via Canvas. This date is reported to the Department of Education for federal financial aid recipients.

Grading Policy:

The final grade will be calculated using the following policy:

| | |
|----------------------------|------|
| Homework Assignments | 30 % |
| Group Project 1 | 15 % |
| Group Project 2 | 11 % |
| Final Project | 20 % |
| Quizzes | 10 % |
| Exam | 9 % |
| Attendance & Participation | 5% |
| | |

4 Class Schedule

| CSE 4360 / CSE 5364 - Autonomous Robots Tentative Lecture and Assignment Schedule Fall 2021 - MW 5:30 - 6:50 - CRB 114 / Microsoft Teams | | | | |
|--|-------|---------------------------------|--|----------------|
| Class | Date | Readings | Lecture Topics | Assignments |
| 1 | 08/25 | | Course Details and Overview | |
| 2 | 08/30 | Craig Ch. 2 | Introduction to Robot Systems | |
| 3 | 09/01 | Craig Ch. 3 | Forward Kinematics | |
| | 09/06 | | <i>Labor Day - No Class</i> | |
| 4 | 09/08 | | Forward Kinematics continued | |
| 5 | 09/13 | Craig 5.1 -5.8 | Jacobian | |
| 6 | 09/15 | Craig 4.1 - 4.4 | Inverse Kinematics | |
| 7 | 09/20 | Craig 9.1 - 9.5 | Robot Dynamics and Control | |
| 8 | 09/22 | | Control and System Identification | Homework 1 due |
| 9 | 09/27 | Latombe pp 153 - 161, 169 - 175 | Motion Planning - Roadmaps | Quiz 1 |
| 10 | 09/29 | Latombe pp 200 - 207, 248 - 268 | Motion Planning - Cell Decomposition | |
| 11 | 10/04 | Latombe pp 295 - 334 | Motion Planning - Potential Field Approaches | |
| 12 | 10/06 | | Nonholonomic Motion Planning | Homework 2 due |
| 13 | 10/11 | Everett Ch. 2 | Robot Sensors | Quiz 2 |
| 14 | 10/13 | Everett pp 91-97 | Robot Sensors | |
| 15 | 10/18 | Ballard 3.1 - 3.3.4 | Basic Vision | |
| 16 | 10/20 | Ballard 3.1 - 3.3.4 | Basic Vision | Project 1 Demo |
| 17 | 10/25 | Ballard 5.1 - 5.3 | Basic Vision | Quiz 3 |
| 18 | 10/27 | Dorst pp. 9 - 51 (by J.Crowley) | Sensing and Control | |
| 19 | 11/01 | Elfes & Burgard | Sensors, Map Construction, and Planning | |
| 20 | 11/03 | Braitenberg Ch. 1 - 5 | Intelligent Robot Behavior | Homework 3 due |
| 21 | 11/08 | Arkin 1.3 - 1.4, 4.1 - 4.3 | Robot Control Architectures | Quiz 4 |
| 22 | 11/10 | Arkin 4.4 - 4.7 | Robot Control Architectures | |
| 23 | 11/15 | | Robot Control Architectures | |
| 24 | 11/17 | Haykin 8.3 - 8.5, 6 - 6.4 | Adaptation and Learning | Project 2 Demo |
| 25 | 11/22 | Arkin 8 - 8.4 | Adaptation and Learning | Quiz 5 |
| | 11/24 | | <i>Thanksgiving - No Class</i> | |
| 26 | 11/29 | Arkin 8 - 8.4 | Adaptation and Learning Summary | |
| 27 | 12/01 | | Summary | Homework 4 due |
| 28 | 12/06 | | In-Class Exam | Exam |
| | TBD | | Final Project Presentation | |

Recommended Readings from:

- John J. Craig, *Introduction To Robotics*, Addison Wesley
- Jean-Claude Latombe, *Robot Motion Planning*, Kluwer Academic Publishers
- H. R. Everett, *Sensors for Mobile Robots*, A K Peters
- Dana H. Ballard and Christopher M. Brown, *Computer Vision*, Prentice-Hall
- L. Dorst, M. Lambalgen, F. Voorbraak (Eds.), *Reasoning with Uncertainty in Robotics*, Springer
- Alberto Elfes, *Using Occupance Grids for Mobile Robot Perception and Navigation*, in IEEE Computer 22(6)
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- Valentino Braitenberg, *Vehicles*, MIT Press
- Ronald C. Arkin, *Behavior-Based Robotics*, MIT Press
- S. Haykin, *Neural Networks*, Macmillan Publishing

This schedule is tentative and subject to change. If changes are necessary they will be announced in class and posted in the schedule on the course page.

5 University Policies and Services

Institution Information

UTA students are encouraged to review the below institutional policies and informational sections and reach out to the specific office with any questions. To view this institutional information, please visit the Institutional Information page (<https://resources.uta.edu/provost/course-related-info/institutional-policies.php>) which includes the following policies among others:

- Drop Policy
- Disability Accommodations
- Title IX Policy
- Academic Integrity
- Student Feedback Survey
- Final Exam Schedule

Face Covering Policy

While the use of face coverings on campus is no longer mandatory, all students and instructional staff are strongly encouraged to wear face coverings while they are on campus. This is particularly true inside buildings and within classrooms and labs where social distancing is not possible due to limited space. If a student needs accommodations to ensure social distancing in the classroom due to being at high risk they are encouraged to work directly with the Student Access and Resource Center to assist in these accommodations. If students need masks, they may obtain them at the Central Library, the E.H. Hereford University Center's front desk or in their department.

Emergency Exit Procedures:

Should we experience an emergency event that requires evacuation of the building, students should exit the room and move toward the nearest exit, which is located down the hallway to the left once exiting the room. When exiting the building during an emergency, do not take an elevator but use the stairwells instead. Faculty members and instructional staff will assist students in selecting the safest route for evacuation and will make arrangements to assist individuals with disabilities.

Academic Success Center [Required for all undergraduate courses] The Academic Success Center (ASC) includes a variety of resources and services to help you maximize your learning and succeed as a student at the University of Texas at Arlington. ASC services include supplemental instruction, peer-led team learning, tutoring, mentoring and TRIO SSS. Academic Success Center services are provided at no additional cost to UTA students. For additional information visit: Academic Success Center (<https://www.uta.edu/student-success/course-assistance>). To request disability accommodations for tutoring, please complete the form at <https://forms.office.com/Pages/ResponsePage.aspx?id=Q1vcXL7XqkyBc3KeOwp2ccSjcIXpSJAqJFuDEhczLIU35DA-6E45-B31B-F5BF0A1B2410>.

Grade Grievances:

Any appeal of a grade in this course must follow the procedures and deadlines for grade-related grievances as published in the current undergraduate catalog.

Drop Policy:

Students may drop or swap (adding and dropping a class concurrently) classes through self-service in MyMav from the beginning of the registration period through the late registration period. After the late registration period, students must see their academic advisor to drop a class or withdraw. Undeclared students must see an advisor in the University Advising Center. Drops can continue through a point two-thirds of the way through the term or session. It is the student's responsibility to officially withdraw if they do not plan to attend after registering. Students will not be automatically dropped for non-attendance. Repayment of certain types of financial aid administered through the University may be required as the result of dropping classes or withdrawing. For more information, contact the Office of Financial Aid and Scholarships (<http://www.uta.edu/aao/fao/>).

Disability Accommodations:

UT Arlington is on record as being committed to both the spirit and letter of all federal equal opportunity legislation, including The Americans with Disabilities Act (ADA), The Americans with Disabilities Amendments Act (ADAAA), and Section 504 of the Rehabilitation Act. All instructors at UT Arlington are required by law to provide "reasonable accommodations" to students with disabilities, so as not to discriminate on the basis of disability. Students are responsible for providing the instructor with official notification in the form of a letter certified by the Office for Students with Disabilities (OSD). Only those students who have officially documented a need for an accommodation will have their request honored. Students experiencing a range of conditions (Physical, Learning, Chronic Health, Mental Health, and Sensory) that may cause diminished academic performance or other barriers to learning may seek services and/or accommodations by contacting:

The Office for Students with Disabilities, (OSD) www.uta.edu/disability or calling 817-272-3364. Information regarding diagnostic criteria and policies for obtaining disability-based academic accommodations can be found at www.uta.edu/disability.

Counseling and Psychological Services, (CAPS) www.uta.edu/caps/ or calling 817-272-3671 is also available to all students to help increase their understanding of personal issues, address mental and behavioral health problems and make positive changes in their lives.

Non-Discrimination Policy:

The University of Texas at Arlington does not discriminate on the basis of race, color, national origin, religion, age, gender, sexual orientation, disabilities, genetic information, and/or veteran status in its educational programs or activities it operates. For more information, visit uta.edu/eos.

Title IX Policy:

The University of Texas at Arlington ("University") is committed to maintaining a learning and working environment that is free from discrimination based on sex in accordance with Title IX of the Higher Education Amendments of 1972 (Title IX), which prohibits discrimination on the basis of sex in educational programs or activities; Title VII of the Civil Rights Act of 1964 (Title VII), which prohibits sex

discrimination in employment; and the Campus Sexual Violence Elimination Act (SaVE Act). Sexual misconduct is a form of sex discrimination and will not be tolerated. For information regarding Title IX, visit www.uta.edu/titleIX or contact Ms. Michelle Willbanks, Title IX Coordinator at (817) 272-4585 or titleix@uta.edu

Academic Integrity:

Students enrolled all UT Arlington courses are expected to adhere to the UT Arlington Honor Code:

I pledge, on my honor, to uphold UT Arlington's tradition of academic integrity, a tradition that values hard work and honest effort in the pursuit of academic excellence.

I promise that I will submit only work that I personally create or contribute to group collaborations, and I will appropriately reference any work from other sources. I will follow the highest standards of integrity and uphold the spirit of the Honor Code.

UT Arlington faculty members may employ the Honor Code in their courses by having students acknowledge the honor code as part of an examination or requiring students to incorporate the honor code into any work submitted. Per UT System Regents' Rule 50101, §2.2, suspected violations of university's standards for academic integrity (including the Honor Code) will be referred to the Office of Student Conduct. Violators will be disciplined in accordance with University policy, which may result in the student's suspension or expulsion from the University. Additional information is available at <https://www.uta.edu/conduct/>.

Electronic Communication:

UT Arlington has adopted MavMail as its official means to communicate with students about important deadlines and events, as well as to transact university-related business regarding financial aid, tuition, grades, graduation, etc. All students are assigned a MavMail account and are responsible for checking the inbox regularly. There is no additional charge to students for using this account, which remains active even after graduation. Information about activating and using MavMail is available at <http://www.uta.edu/oit/cs/email/mavmail.php>.

Campus Carry:

Effective August 1, 2016, the Campus Carry law (Senate Bill 11) allows those licensed individuals to carry a concealed handgun in buildings on public university campuses, except in locations the University establishes as prohibited. Under the new law, openly carrying handguns is not allowed on college campuses. For more information, visit <http://www.uta.edu/news/info/campus-carry/>

Student Feedback Survey:

At the end of each term, students enrolled in face-to-face and online classes categorized as "lecture", "seminar", or "laboratory" are directed to complete an online Student Feedback Survey (SFS). Instructions on how to access the SFS for this course will be sent directly to each student through MavMail approximately 10 days before the end of the term. Each student's feedback via the SFS database is aggregated with that of other students enrolled in the course. Students' anonymity will be protected to the extent that the law allows. UT Arlington's effort to solicit, gather, tabulate, and publish student feedback is required by state law and aggregate results are posted online. Data from SFS is also used for faculty and program evaluations. For more information, visit <http://www.uta.edu/sfs>.

Final Review Week:

A period of five class days prior to the first day of final examinations in the long sessions shall be designated as Final Review Week. The purpose of this week is to allow students sufficient time to prepare for final examinations. During this week, there shall be no scheduled activities such as required field trips or performances; and no instructor shall assign any themes, research problems or exercises of similar scope that have a completion date during or following this week unless specified in the class syllabus. During Final Review Week, an instructor shall not give any examinations constituting 10% or more of the final grade, except makeup tests and laboratory examinations. In addition, no instructor shall give any portion of the final examination during Final Review Week. During this week, classes are held as scheduled. In addition, instructors are not required to limit content to topics that have been previously covered; they may introduce new concepts as appropriate.

Emergency Exit Procedures:

Should we experience an emergency event that requires us to vacate the building, students should exit the room and move toward the nearest exit, which is located to the right or left of the back room exit and out of the building. When exiting the building during an emergency, one should never take an elevator but should use the stairwells. Faculty members and instructional staff will assist students in selecting the safest route for evacuation and will make arrangements to assist individuals with disabilities.

Student Support Services:

UT Arlington provides a variety of resources and programs designed to help students develop academic skills, deal with personal situations, and better understand concepts and information related to their courses. Resources include tutoring, major-based learning centers, developmental education, advising and mentoring, personal counseling, and federally funded programs. For individualized referrals, students may visit the reception desk at University College (Ransom Hall), call the Maverick Resource Hotline at 817-272-6107, send a message to resources@uta.edu, or view the information at <http://www.uta.edu/universitycollege/resources>

The IDEAS Center

(2nd Floor of Central Library) offers FREE tutoring to all students with a focus on transfer students, sophomores, veterans and others undergoing a transition to UT Arlington. Students can drop in, or check the schedule of available peer tutors at www.uta.edu/IDEAS, or call (817) 272-6593.

The English Writing Center

(411LIBR): The Writing Center offers FREE tutoring in 15-, 30-, 45-, and 60-minute face-to-face and online sessions to all UTA students on any phase of their UTA coursework. Register and make appointments online at <https://uta.mywconline.com>. Classroom visits, workshops, and specialized services for graduate students and faculty are also available. Please see www.uta.edu/owl for detailed information on all our programs and services.

The Library's 2nd floor Academic Plaza offers students a central hub of support services, including IDEAS Center, University Advising Services, Transfer UTA and various college/school advising hours. Services are available during the library's hours of operation. <http://library.uta.edu/academic-plaza>

6 Library - library.uta.edu

Resources for Students

Research or General Library Help

Academic Plaza Consultation Services: library.uta.edu/academic-plaza

Ask Us: ask.uta.edu/

Library Tutorials: library.uta.edu/how-to

Subject and Course Research Guides: libguides.uta.edu

Librarians by Subject: library.uta.edu/subject-librarians

Research Coaches: <http://libguides.uta.edu/researchcoach>

Resources

A to Z List of Library Databases: libguides.uta.edu/az.php

Course Reserves: pulse.uta.edu/vwebv/enterCourseReserve.do

Study Room Reservations: openroom.uta.edu/